

CHAPTER 8 LOCATION SURVEYING AND MAPPING

8-1. Introduction.

a. The purpose of this chapter is to describe and discuss the location surveying and mapping considerations that should be addressed by the project team for an OE project. The project team should develop site-specific location surveying and mapping requirements for inclusion in the SOW for each OE project. Attachment 8-1 is a checklist of location surveying and mapping considerations.

b. USACE has various contract vehicles that may be used for obtaining location surveying and mapping services. Services may be supplied by the government as Government Furnished Information/Government Furnished Equipment or may be requested within the SOW of the OE project. Some OE projects may not require any specialized capabilities, while others may require comprehensive capabilities.

8-2. Overview. This chapter presents guidance in developing requirements for location survey and mapping associated with an OE project, specific SOW specifications, and technical or management considerations. There are many surveying and mapping techniques that may be used to acquire planimetric, topographic, hydrographic, or feature attribute data required in support of an OE project. Specifications for obtaining this data should be “performance-based” and not overly prescriptive or process oriented in accordance with EM 1110-1-2909, Geospatial Data and Systems. They should not be a survey procedural instruction. Project specifications should set forth the end results to be achieved and not the means, or technical procedures, used to achieve those results. They should succinctly define the location surveying and mapping requirements as derived from the functional project requirements developed by the project team and reference EM 1110-1-2909 and other applicable industry standards.

8-3. Data Quality Objectives. Prior to developing data quality objectives for the location surveying and mapping task, the project team should review the archival records of the project area or installation in which the project is located and inventory all existing survey and mapping data. Following the completion of these tasks, the project team should develop site-specific data quality objectives in the following areas:

a. **Measurement Units.** Location surveying and mapping performed in support of an OE response should be recorded and plotted in the units prescribed for the project by the district or project sponsor.

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b. Spatial Coordinate Reference System.

(1) All OE projects should be adequately connected to nationwide or worldwide geographic reference systems directly derived from, or indirectly related to, GPS satellite observations where practical and feasible. Location surveys will be connected to existing local, state or national control markers and referenced to an appropriately recognized installation, local, state, or worldwide coordinate system as specified by the project team. The project team should select a spatial coordinate reference system that is compatible with existing district or project sponsor surveying and mapping activities.

(2) The base mapping should be accomplished in the appropriate English or metric State Plane Grid Coordinate System for the state where the project is located unless an equivalent local system is preferred by the customer at this location.

c. Control Markers. Project control markers may consist of markers and/or benchmarks established by any federal, state, local, or private agency with positional data within the minimum acceptable accuracy standards prescribed by the project team. The project team may require an increase in existing project control markers. Ties to local USACE or installation project control and/or boundary markers are absolutely essential and critical except when unfeasible or cost prohibitive. In order to minimize scale and orientation errors, at least two existing markers should be used as a baseline for the project geospatial coordinate reference system.

d. Accuracy. Every observed or measured spatial data element contains errors of a certain magnitude due to a variety of causes. The project team should evaluate data requirements and develop acceptable limits of error (accuracy and precision) based upon the nature and purpose of each location surveying and mapping activity or product. Engineering and construction surveys are normally specified and classified based on the minimum acceptable horizontal (linear) point closure ratio and vertical elevation difference standard.

e. Geospatial Data Standards. The project team should develop site-specific standards for the format, transfer, and storage of all location surveying and mapping data. Factors influencing formulation of project-specific specifications include:

(1) Compatibility with current OE MCX and district hardware and software platforms without modification or additional software;

(2) Existing digital data and geo-spatial referenced mapping; and

(3) Usability by all parties of concern, including stakeholders.

f. Quality Control. The project team should state in the SOW that quality control of location surveying and mapping activities and products will be performed by the contractor and

include independent tests which may be periodically reviewed by the government. USACE quality assurance and testing functions should focus on whether the contractor meets the required performance specifications.

g. Standardization. Standardization of equipment and instruments used in acquiring geospatial data and producing location survey and mapping products is required to improve the accuracy of the integrated conclusions. The project team should review the need for and develop minimum acceptable criteria for review of validation and calibration reports.

8-4. Statement of Work.

a. General. The Location Surveying and Mapping task of each SOW for OE projects should be prepared by project team personnel with a detailed knowledge of project history, site conditions, site-specific data requirements, and location survey and mapping methodologies. The SOW should require consideration of the following in development of the Work Plan:

- (1) Project and property boundaries;
- (2) UXO/OE types, hazard levels, and contamination levels;
- (3) Project location, size, topography, and vegetative cover;
- (4) Extent of existing planimetric features;
- (5) Density and accuracy of existing control markers;
- (6) Mission and objectives of OE response action;
- (7) Positioning requirements of proposed geophysical detection systems; and
- (8) Data formatting, transfer, and storage.

b. Personnel Requirements. The project team should ensure that the SOW discusses personnel requirements for a Registered or Professional Land Surveyor and a qualified UXO technician.

(1) Registered or Professional Land Surveyor (RLS/PLS). The project team should ensure that the OE project SOW specifies that all location surveying and mapping activities should be completed under the responsible charge of a RLS/PLS. The RLS/PLS should be registered and/or licensed by the appropriate Board of Registration, or an acceptable equivalent, for the state in which the work will be conducted. The RLS/PLS will only be required to sign drawings that contain boundaries, legal descriptions, or parcel closure information. Signatures are not required for EE/CA grid location and ordnance location data. In addition, the Field Surveyor

assigned to the OE project should have a minimum of five years experience as a Survey Party Chief.

(2) UXO Technician II. The project team should also assure that the SOW requires a qualified UXO Technician II to accompany the Field Surveyor during all field surveying and mapping activities. The UXO Technician II should conduct visual surveys for surface ordnance prior to the Field Surveyor entering a suspected UXO contaminated area, and a survey with a geophysical instrument of each intrusive activity site to ensure the site is anomaly free prior to installation of monuments, driving stakes, or performing any other intrusive activity. Based on site conditions, it is possible that a UXO Technician II will not be required in all areas at all times after the initial site visit. However, such a decision should be made jointly by the UXO Technician II and the USACE OE Safety Specialist who may rescind or modify it at any time.

c. Safety. It is the responsibility of the project team to assure that the contractor is informed in the SOW to follow the safety requirements in EM 385-1-1, USACE Safety and Health Requirements Manual.

d. Resources. For general guidance in the development of surveying and mapping specifications, the project team may reference Chapter 11, "Accuracy Standards for Engineering, Construction, and Facility Management Surveying and Mapping", of EM 1110-1-2909. GPS surveying services may be required as an integral part of the location surveying and mapping effort. EM 1110-1-1003, NAVSTAR Global Positioning System Surveying, provides technical specifications and procedural guidance for surveying with GPS and includes a guide specification for development of SOWs with GPS survey requirements.

8-5. Location Surveys and Mapping Plan.

a. General. Prior to initiating field activities, a Location Surveys and Mapping Plan should be prepared. This plan, which is a chapter in the Work Plan, is prepared to describe the project requirements, proposed technical methodologies and procedures, and equipment recommendations for all surveying and mapping activities that will take place during an OE project.

b. Contents. When reviewing the Location Surveys and Mapping Plan, the project team should ensure that the following elements are addressed:

(1) Existing control markers (density, accuracy, and accessibility);

(2) Project and grid controls (requirements, material, location, construction, identification, and accuracy);

(3) Proposed methods and procedures (equipment, personnel, safety, work instructions, data processing and production rates);

- (4) Quality control (instrument calibration, data validation);
- (5) Interim reporting; and
- (6) Final reports and maps.

c. **Review and Approval.** The Location Surveys and Mapping Plan should be submitted as a chapter of the Work Plan to the PM and Design Center POC. The Design Center POC should route the plan to the appropriate USACE technical staff for review and comment. Once approved by the project team and CO, the Location Surveys and Mapping Plan represents the standard to which all survey and mapping activities are compared to assure compliance during the project. In the case of contractor execution, the approved Location Surveying and Mapping Plan is contractually binding.

8-6. Planning Considerations. Each OE project requires selection of location surveying and mapping equipment and methodologies that will accomplish the end objective without wasting manpower, time, and money. The project team should ensure that the following items are considered when planning for the location surveying and mapping task.

a. **Spatial Data Reference System.** Unless otherwise specified, all horizontal control will be based on either the English or metric system and reference to the NAD83 and the State Plane Grid System for the project location. Vertical control, if required, will also be based on either the English or metric system and referenced to the NAVD88.

b. **Project Control Markers.**

(1) The requirements for new or additional project control markers should be based on the availability of existing control markers, the type of location surveying equipment proposed, and the level of accuracy required for the type of activities proposed under the specific OE response project. Permanent concrete monuments are typically used for project control. Specifications for permanent markers are set forth in EM 1110-1-1002, Survey Markers and Monumentation and should be reviewed in consideration of the following:

- (a) Located within the project limits with a minimum separation of 300 feet;
 - (b) Set 10 meters (m) from the edge of any existing road inside the project limits; and
 - (c) Constructed with the top set flush with the ground and the bottom at a minimum of 0.6 meters below frost depth.
- (2) Accuracy.

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(a) The minimum accuracy standards for horizontal and vertical control will be Class I, Third Order, or better. Horizontal control will be based on either the English or metric system and referenced to the NAD83 and the State Plane Coordinate Grid System. Vertical control, if required, will also be based on either the English or metric system and referenced to NAVD88.

(b) If aerial photographs or orthophotography are used to provide the survey, the aerial targets used for control points will meet the same horizontal and vertical accuracy requirements detailed above.

(3) Monument Caps.

(a) The caps for any new monuments established should be 3-1/4 to 3-1/2 inch domed brass, bronze or aluminum alloy and stamped in a consecutively numbered sequence. The proposed identification stamping for each monument will be provided in the location surveying and mapping plan consistent with the following:

(Project Name) - (Numerical Sequence) - (Year) (Contracting OE Design Center)

(b) The dies for stamping the numbers and letters into these caps will be 1/8-inch to 3/16-inch in size. All coordinates and elevations will be shown to the closest one-thousandth of a meter (0.001m) and one-hundredth of a foot (0.01 ft).

(4) Description Cards. A Description Card should be required for all control monuments established or used for the OE response. The Description Cards should be prepared on cards 5 inches by 8 inches describing one monument per card, or on an 8-1/2 by 11 inch sheet of bond paper containing descriptions of two monuments. The Description Card should show the following:

(a) A north arrow;

(b) A sketch of each monument and its location relative to reference marks, buildings, roads, railroads, towers, trees, etc.;

(c) A typed description telling how to locate the monument from a well known and easily identifiable point;

(d) The monument's name or number; and

(e) The final adjusted coordinates and elevations in meters and feet (to the closest 0.001m and 0.01 feet).

c. Project Boundaries. Project boundaries should be delineated with permanent or semi-permanent markers, such as iron pipe or pins consistent with state or local subdivision

requirements. The accuracy standards for the location of project boundaries should be equal or greater than minimum standards for property boundary surveys established by the state within which the project is located.

d. Local Control Points. Local control points (i.e., grid corners, aerial targets) should be established using plastic or wooden hubs unless otherwise specified by the project team. The accuracy standards for aerial targets established as control points for aerial photographs or orthophotography should be the same as those prescribed for project control monuments. Accuracy standards for grid corners should be consistent with the mission and objectives of the OE response effort.

e. Anomalies and Recovered UXO. All recovered UXO/OE and any subsurface geophysical anomalies not completely investigated should be located. Each location will be estimated or measured for an approximate accuracy of plus or minus one foot.

8-7. Mapping.

a. The project team should review the extent of mapping requirements to be included in each OE project SOW. The project team should assure that the SOW states that all maps and drawings to be provided under the task will be prepared in accordance with Chapter 9 of this manual and sealed and signed by the RLS/PLS. Tri-Service Computer-aided Design and Drafting (CADD)/GIS Technology Center standards should be specified for all location survey and mapping deliverables of CADD, GIS, and other spatial and geospatial data in accordance with EM 1110-1-2909.

b. The project team should ensure that the following maps are provided:

(1) Location Maps. A location map showing the project site and surrounding points of interest should be required. The map(s) should be produced at a scale no smaller than 1:2,400 or 1":200'.

(2) Project Map.

(a) A map of all project related points of interest should be produced and delivered electronically at a scale specified by contract requirements. The Project Map should show the location and identification of all of the project control monuments recovered and/or established at the site in support of the OE response, local project controls, significant planimetric features, project boundaries, and property boundaries (if in close proximity to project boundaries). The location of recovered UXO/OE should also be plotted and identified on the map unless individual grid maps are also required.

(b) General project map requirements should also include grid, magnetic, and true north arrows with their angular differences; grid lines or tic marks at systematic intervals with values

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shown on the edges of the map; and a legend showing the standard symbols used for the mapping.

(3) Grid Maps. If required, individual maps for each grid should be prepared at a scale no smaller than 1:2,400 or 1":200'. The Grid Maps should include the plotted location of each surface UXO/OE, verified subsurface UXO/OE recovered, and each subsurface geophysical anomaly not completely investigated within the grid. Other notable planimetric features within the grid should also be sketched on the individual Grid Maps.

8-8. Deliverables. All deliverables should be submitted in accordance with contract requirements. When applicable, deliverables should be submitted in electronic format. The following deliverables should be submitted to the project team following the location survey and mapping task (the submittal dates should be specified for each delivery order):

- a. Original copies of all field books, layout sheets, computation sheets, abstracts and computer printouts;
- b. Tabulated listing of all project control markers established and/or used in support of the OE response showing adjusted horizontal and vertical positional values in meters and feet;
- c. Tabulated listing of all UXO/OE recovered and any specific anomalies not completely investigated;
- d. Completed description cards;
- e. Unique items created and/or used to create the end products and the narrative and description required by the SOW;
- f. Required location, project, and grid maps;
- g. The negatives and three sets of prints of the aerial photographs taken for the project, if aerial photography is required in the SOW; and
- h. All maps should be drawn on 841 mm by 594 mm (standard metric A-1 size drawing) reproducible (mylar) drawings generated by the CADD system. One original mylar and five blue-line prints of each final map and two copies of the digital data should be delivered to the Design Center.

ATTACHMENT 8-1
LOCATION SURVEYING AND MAPPING CHECKLIST

Project Name: _____
 Project Location: _____
 Design Center POC: _____
 Preparer's Name and Title: _____
 Date of Preparation: _____

Y N N/A

SOW Requirements

- | | | | |
|---|-------|-------|-------|
| 1. Has the Location Surveying and Mapping task in the SOW been prepared by project team personnel with a detailed knowledge of project history, site conditions, site-specific data requirements and location survey and mapping methodologies? | _____ | _____ | _____ |
| 2. Does the SOW state that all surveying and mapping activities must be conducted under the responsible charge of a Registered or Professional Land Surveyor registered and/or licensed in the State in which the work will be conducted? | _____ | _____ | _____ |
| 3. Does the SOW state that the Field Surveyor assigned to the project must have a minimum of 5 years experience as a Survey Party Chief? | _____ | _____ | _____ |
| 4. Does the SOW require that a qualified UXO Technician II accompany the Field Surveyor at all times, unless it is decided by the UXO Technician II and the OE Safety Specialist that the UXO Technician II is not required? | _____ | _____ | _____ |
| 5. Does the SOW state that the contractor must follow the safety requirements in EM 385-1-1, US Army Corps of Engineers Safety and Health Requirements Manual? | _____ | _____ | _____ |
| 6. Does the SOW specify the requirements for control point establishment? | _____ | _____ | _____ |

	Y	N	N/A
7. Does the SOW state the specifications for monument caps and monument identification?	_____	_____	_____
8. Does the SOW give procedures for plotting the control points?	_____	_____	_____
9. Does the SOW give requirements for grid corner establishment?	_____	_____	_____
10. Does the SOW state that the Registered Land Surveyor/Professional Land Surveyor should sign drawings that contain boundaries, legal descriptions or parcel closure information?	_____	_____	_____
11. Does the SOW prescribe the units to be used for recording and plotting location survey and mapping activities, as specified by the district or project sponsor?	_____	_____	_____
12. Does the SOW specify the spatial coordinate reference system to be used?	_____	_____	_____
13. Is the chosen spatial coordinate reference system compatible with existing district or project sponsor surveying and mapping activities?	_____	_____	_____
14. Does the SOW require that location surveys be connected to existing local, state or national control monuments and referenced to an appropriately recognized installation, local state, or worldwide coordinate system as specified by the project team?	_____	_____	_____
15. Does the SOW specify the minimum acceptable accuracy standards for positional data for project control markers (i.e., monuments, benchmarks)?	_____	_____	_____
16. Is densification of the existing project control markers required?	_____	_____	_____
17. If densification of existing project control markers is required, is this specified in the SOW?	_____	_____	_____
18. Does the SOW specify that at least two existing markers will be used as a baseline for the project geospatial coordinate reference system?	_____	_____	_____

	Y	N	N/A
19. Has the project team specified acceptable limits of error in terms of accuracy and precision based on the nature and purpose of each location surveying and mapping activity or product?	_____	_____	_____
20. Has the project team developed site-specific standards for the format, transfer and storage of all location surveying and mapping data?	_____	_____	_____
21. Were the following items considered in developing the standards for format, transfer and storage of data:			
• Compatibility with current OE MCX and district hardware and software platforms without modification or additional software?	_____	_____	_____
• Existing digital data and geospatial referenced mapping?	_____	_____	_____
• Usability by all parties of concern, including stakeholders?	_____	_____	_____
22. Does the SOW require contractor quality control of location surveying and mapping activities and products, including independent tests which may be periodically reviewed by the government?	_____	_____	_____
23. Has the project team established minimum acceptable criteria for standardization of equipment and instruments used in acquiring geospatial data and producing location survey and mapping products?	_____	_____	_____
24. Has the project team established minimum acceptable criteria for productivity?	_____	_____	_____
25. Are the following deliverables specified in the SOW:			
• Original copies of all field books, layout sheets, computation sheets, abstracts and computer printouts?	_____	_____	_____

	Y	N	N/A
• Tabulated listing of all project control monuments established and/or used in support of the OE response showing adjusted horizontal and vertical positional values in meters and feet?	_____	_____	_____
• Tabulated listing of all UXO/OE recovered and any specific anomalies not completely investigated?	_____	_____	_____
• Completed description cards?	_____	_____	_____
• Unique items created and/or used to create the end products and the narrative and description required?	_____	_____	_____
• Required location, project and grid maps?	_____	_____	_____
• The negatives and three sets of prints of the aerial photographs taken for the project, if aerial photography is required in the SOW?	_____	_____	_____
• Map drawn on 841 mm by 594 mm (standard metric A-1 size drawing) reproducible (mylar) drawings and generated by the CADD system?	_____	_____	_____
• One original mylar and five blueline prints of each final map and two copies of the digital data will be delivered to the Design Center?	_____	_____	_____
<u>Location Surveys and Mapping Plan</u>	_____	_____	_____

Are the following elements addressed in the Location Surveys and Mapping Plan:

1. Existing Control Markers:

• Density?	_____	_____	_____
• Accuracy?	_____	_____	_____
• Accessibility?	_____	_____	_____

	Y	N	N/A
2. Project and Grid Controls (New):			
• Requirements?	_____	_____	_____
• Material?	_____	_____	_____
• Location?	_____	_____	_____
• Construction?	_____	_____	_____
• Identification?	_____	_____	_____
• Accuracy?	_____	_____	_____
3. Proposed Methods and Procedures:			
• Equipment?	_____	_____	_____
• Personnel?	_____	_____	_____
• Safety?	_____	_____	_____
• Work Instruction?	_____	_____	_____
• Data Processing?	_____	_____	_____
• Production Rates?	_____	_____	_____
4. Quality Control:			
• Instrument Calibration?	_____	_____	_____
• Data Validation?	_____	_____	_____
5. Interim Reporting?	_____	_____	_____
6. Final Reports and Maps?	_____	_____	_____
<u>Electronic Submittal</u>			
1. Are disks readable?	_____	_____	_____
2. Are the disks labeled and dated?	_____	_____	_____

	Y	N	N/A
3. Are the files in the correct format, as requested in SOW? (e.g., DOS, Win 95/98/NT, UNIX, etc.)	_____	_____	_____
4. Do they follow the Tri-Service Spatial Data Standard (TSSDS), if required?	_____	_____	_____
5. Are all of the detailed files included on the disks to make a complete data set?	_____	_____	_____
6. Is each individual file readable and useable?	_____	_____	_____
7. Is the file located electronically (geo-spatially) at the correct location on the ground?	_____	_____	_____
8. Is the coordinate system correct?	_____	_____	_____
9. Does the file contain North arrow, scale, specific spot coordinates for control points, and a grid or coordinate grid system displayed as part of the border or boundary?	_____	_____	_____
10. Are all files geographically located in the correct plane and datum?	_____	_____	_____
11. Are the X, Y, Z coordinates correct within the file?	_____	_____	_____
12. Are the correct number of copies submitted, depending on the submittal stage?	_____	_____	_____
<u>Paper or Hard Copy Submittal</u>			
1. Is the sheet the requested size?	_____	_____	_____
2. Is it plotted on the correct media (e.g., paper, vellum, mylar, blueline, etc.)?	_____	_____	_____
3. Does it contain the correct border?	_____	_____	_____
4. Is the correct grid system and associated control shown on the sheet?	_____	_____	_____
5. Has the title block been completed (i.e., all required blocks filled in)?	_____	_____	_____
6. Is the sheet plotted at the scale shown in the title block?	_____	_____	_____
7. Are there grid marks or tics (meters, feet, both, Lat/Lon, Local, etc.)?	_____	_____	_____

	Y	N	N/A
8. Is there a North arrow (magnetic declination, true North, and grid North) and graphical scale shown on the sheet, both graphically and printed text?	_____	_____	_____
9. Is there a legend for associated symbols on the sheet? Or, are all symbols used in a project shown on one legends and notes page?	_____	_____	_____
10. Is the sheet developed based on the TSSDS and the Tri-Service CADD Standard for line weights, color, and other graphical detail?	_____	_____	_____
11. If the drawing is to be certified or stamped, are the correct seals, stamps, and signatures contained on the sheet and legible?	_____	_____	_____
12. Is the state registration seal and associated state registration number shown on the sheet?	_____	_____	_____
13. Are all the sheets plotted and an index sheet prepared to make a complete set of drawings to convey a completed mapping product?	_____	_____	_____
14. Are all sheets numbered in a sequential order in the set?	_____	_____	_____
15. Are all sheets included in the set?	_____	_____	_____
16. Are the correct number of copies submitted?	_____	_____	_____
17. Are boundaries of required clearance or remediation areas shown?	_____	_____	_____
18. Are grids of areas investigated shown?	_____	_____	_____
19. Are the coordinates of grid corners shown on a drawing or in a table?	_____	_____	_____
20. Was the GIS submittal required? If so:	_____	_____	_____
• Are all required databases and map layers submitted?	_____	_____	_____
• Is the data submitted in the correct format (MGE, ArcView, MapInfo, etc.)?	_____	_____	_____
• Is the Users Manual modified for any project specific requirements or software modification from the standard?	_____	_____	_____